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RESECTION OF LUNG CANCER INVADING THE DIAPHRAGM

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Each year, stage III non-small-cell lung cancer (NSCLC) is diagnosed in approximately 30,000 patients. Locally advanced NSCLC (stage IIIA) includes a group of biologically diverse tumors with subgroups of truly locally advanced disease—T3 tumors and advanced locoregional disease with the presence of N2 disease. The prognosis of patients with a diagnosis of stage III lung cancer is mainly dependent on the status of the mediastinal nodes. Good long-term results are achieved in patients with N0 disease, whereas patients with N2 disease are poor candidates for resection as a primary treatment.[1-3] Information is not available on results of surgical treatment of patients with stage III disease and tumors involving the diaphragm.

Patients and methods. From January 31, 1974, to August 17, 1995, a total of 4668 patients underwent exploration for resection of NSCLC at Memorial Hospital. By analyzing our database we identified eight patients (0.17%) who had exploratory thoracotomy for resection of NSCLC invading the diaphragm. The medical records of these eight patients were retrospectively analyzed. Data are reported as mean ± standard deviation. Survival data are reported as mean and 95% confidence interval (CI) for the mean. The Kaplan-Meier method was used to calculate actuarial survival.

Results. The demographics of these eight patients are shown in Table I. The mean age at diagnosis was 65.8 ± 10.2 years, ranging from 52.6 to 82.4 years. The most common symptoms were cough in four patients, hemoptysis in two patients, and chest pain in one patient. One patient had clubbing of the fingers. Three patients were free of symptoms. All patients smoked. The mean time from first symptoms to referral for treatment was 25.1 ± 16.6 weeks, ranging from 5.3 to 49 weeks. The histologic diagnosis was made by bronchoscopic examination in four patients and by fluoroscopic guided needle biopsy in two. In two patients the diagnosis was made in the operating room. Four tumors were on the right side and four on the left side. Two patients underwent mediastinoscopy, both studies yielding negative results. The other six did not undergo preoperative mediastinoscopy. Among the eight patients, diaphragmatic invasion was not suspected at exploration in six and it was suspected before the operation in one; the eighth patient was treated by exploration, immediate closure of the incision, subsequent chemotherapy and radiation therapy, and then complete resection. Surgical treatment included wedge resection in one patient, lobectomy in four, bilobectomy in one, and right pneumonectomy in one. One patient was deemed to have unresectable disease and received radiotherapy via afterloading catheters. The diaphragm was resected en bloc with the tumor in seven patients, and all but one underwent primary closure of the diaphragm; one patient had reconstruction with polytetrafluoroethylene mesh.

Seven patients had squamous cell carcinoma and one patient had adenosquamous carcinoma. The tumor pathologically invaded the diaphragmatic muscle in all resected specimens. Final pathologic stage was T3 N0 in four patients and T3 N2 in four patients. All patients survived the operation and were discharged from the hospital. Complications were minor. Mean hospital stay was 8.6 ± 9.4 days, ranging from 4 to 32 days. Follow-up data were complete on all patients. Survival was 52.8 weeks (95% CI 12.4 to 93.1 weeks). Of the four patients with N2 disease, all died of recurrent disease with a mean survival of 92.1 weeks (95% CI 28.4 to 155.8 weeks). Of patients with N0 disease, one is alive 69.4 weeks after the operation and the other three died of causes unrelated to their disease. In four patients who had N2 disease, the recurrent disease occurred 53.6 ± 75.0 weeks after the operation. The site of first recurrence was the brain in three patients and axillary node in one patient. Survival after recurrence was only 27.4 ± 34.1 weeks.

Discussion. To our knowledge, this is the first report in the English literature on patients undergoing surgical resection for diaphragmatic invasion. It is possible that the reason for the rarity of this condition is that many patients have late disease in the form of T4 tumors with malignant pleural effusion when first referred for treatment. Because resectable lung cancer invading the diaphragm is a rare entity (only 0.17% of all patients having exploratory operations), very little information is available on the proper management strategy. In our series, diaphragmatic invasion was not suspected before the operation. Most patients had symptoms related to lung cancer but none had symptoms that could point the surgeon to the diaphragm (shoulder pain, for example). Technically, in six of seven patients the diaphragm was reconstructed by primary repair; only one patient (patient 5) required mesh reconstruction. It is interesting that practically all patients had squamous cell carcinoma, whereas one would expect that adenocarcinoma would comprise at least half of all specimens. Most patients underwent some form of pulmonary resection, although one patient could not withstand resection. This patient was treated with radiation and chemotherapy and survived 28 weeks. Four patients had N2 disease, discovered during exploration, and all

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Table I. *Demographics*

Patient	Sex	Age (yr)	Stage	Status	Survival (wk)	Cause of death
1	F	69	T3 N2	DOD	23	Brain metastasis
2	M	62	T3 N2	DOD	103	Brain metastasis
3	M	53	T3 N2	DOD	28	Generalized disease
4	F	64	T3 N2	DOD	170	Brain metastasis
5	M	52	T3 N0	DOC	17	Arrhythmia
6	F	82	T3 N0	DOC	7	MI
7	M	75	T3 N0	DOC	5	MVA
8	M	67	T3 N0	NED	69	

DOD, Died of disease; *DOC,* died of other causes; *NED,* no evidence of disease; *MI,* Myocardial infarction; *MVA,* motor vehicle accident.

died of distant disease. Detection of N2 disease becomes of paramount importance in view of recent data suggesting that preoperative chemotherapy improves survival in such patients.[4, 5] Our follow-up on patients without involved mediastinal nodes is disappointing, because three of four patients died relatively soon after the operation of causes unrelated to their lung cancer. To our knowledge, none had evidence of disease at the time of death. Postoperative follow-up in the single patient who is free of disease is only 69.4 weeks.

In summary, resectable tumors invading the diaphragm are rare. Careful evaluation of the mediastinum with mediastinoscopy is important to detect N2 disease and select those patients for preoperative chemotherapy. Most tumors found to invade the diaphragm during surgery can be resected and the diaphragm closed primarily. The survival benefit of resecting the tumor in patients with diaphragmatic invasion is not clear. Because this is an unusual entity, it may be difficult to determine whether surgery is the adequate treatment modality. We believe that in patients without involved mediastinal nodes and in good general condition, diaphragmatic invasion should be treated by resecting the tumor en bloc with the diaphragm.

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PULMONARY ROOT TRANSLOCATION FOR BIVENTRICULAR REPAIR OF DOUBLE-OUTLET LEFT VENTRICLE WITH ABSENT SUBPULMONIC CONUS

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Double-outlet left ventricle (DOLV) is a rare form of malpositioned great arteries in which the aorta and the main pulmonary artery arise from the left ventricle in the presence of a malalignment ventricular septal defect.

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DOLV occurs as a spectrum and has been found with a variety of associated lesions, most commonly pulmonic or subpulmonic stenosis (or both), tricuspid valve anomalies, and hypoplasia of the right ventricle.[1] Depending on the size and function of the right ventricle and tricuspid valve, along with the size and position of the ventricular septal defect, DOLV is usually amenable to biventricular repair. Traditionally, this has been accomplished by either an intraventricular baffle procedure or ventricular septal defect closure with conduit reconstruction of the right ventricular outflow tract (Rastelli repair).[2, 3] The former technique is not suitable for all forms of DOLV, especially those with a restrictive interventricular communication or subpulmonic stenosis. The Rastelli approach is suboptimal, especially in children, because they will almost inevitably outgrow their conduit and require conduit replace-